Frozen Fluidity:

Recursive Coherence as the Ontological Substrate

of Time and Quantum Measurement

Benjamin James

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Abstract
This paper introduces a foundational model for reinterpreting quantum mechanics and temporality through the lens of recursive coherence and fluid dynamics. Rejecting the traditional notion of time and measurement as artificial constructs, I posit both arise from structural perturbations within a coherence substrate, a dynamic field of recursively stable potential. Quantum superposition is reframed as a fluid coherence state, wherein measurement corresponds to a localized phase transition that temporarily crystallizes into an observable particle. Once the perturbation subsides, the system reverts to fluidic superposition. Time is not a universal axis but a measure of persistence within this coherence field, manifesting as the rate at which structural gradients evolve or dissolve. This model subsumes the measurement problem, collapses the necessity of Many-Worlds branching, and redefines probability as a coherence-weighted metric rather than fundamental indeterminacy. Drawing from prior work in Adaptive Quantum Coherence and Temporal Impermanence, this framework presents a unified substrate from which both time and quantum states emerge, governed by a single recursive evolution principle. The result is a theory that aligns information, entropy, and observation under coherent dynamics of frozen fluidity.

Keywords: quantum coherence, superposition, measurement problem, temporal emergence, recursive systems, phase transition, wavefunction dynamics, coherence fluid, entropy, probability

Introduction

Contemporary physics remains divided by foundational inconsistencies in its treatment of quantum measurement and temporal evolution. Quantum mechanics accurately predicts outcomes yet fails to offer a coherent ontology: what constitutes a quantum particle, when and how wavefunction collapse occurs, and why probability manifests in the specific form dictated by the Born rule. Simultaneously, time is inconsistently modeled: as a parameter in quantum theory, as a dimension in relativity, and as an emergent effect in thermodynamic systems. These treatments are not only fragmented, but mutually incompatible under recursive scrutiny.

This paper addresses these fractures by proposing a unified framework rooted in recursive, coherence-first principles. I assert that neither time nor particles are ontologically fundamental; both are emergent phenomena arising from recursive perturbations in a coherence substrate. Instead of treating quantum states as static or probabilistic, I conceptualize them as fluid coherence fields. Dynamic, recursive structures whose stability gives rise to observables.

Measurement is reinterpreted as a localized phase transition in this fluid, temporarily freezing part of the system into a crystallized state that registers as a particle. Time itself is redefined as the persistence gradient of coherence: it flows not because clocks tick, but because structure holds. This coherence-fluid paradigm dissolves longstanding paradoxes, integrates thermodynamics, and reframes quantum behavior as the emergent topology of recursive stability.

The Coherence Substrate

At the foundation of this framework lies the concept of a coherence substrate, defined here as *coherence-fluid*: a pre-spatial, pre-temporal field composed not of matter or energy, but of recursive structural potential. Throughout this paper, ‘fluid’ refers to a metaphorical substrate of dynamic coherence gradients, not a physical medium. It models structural adaptability, not material flow. Coherence operates orthogonally to energy. It measures structural persistence and alignment, not quantity of work or heat.

Unlike conventional fields defined over spacetime coordinates, the coherence field is defined over gradients of internal consistency. A system exists within this field if and only if it maintains sufficient recursive alignment to persist. This is formalized by the Persistence Equation from the Recursive Coherence framework:

$$\frac{dC}{dt} = \Gamma C^n - \lambda C + \eta(\nabla S \cdot \nabla \Omega)$$

where C is coherence density, Γ represents feedback amplification, λ is entropy leakage, and η modulates responsiveness to entropy (∇S) and option space ($\nabla \Omega$).

In this substrate, quantum superposition corresponds to high-coherence states. Spherical distributions of potential outcomes not yet resolved into distinct observables. Time and particles emerge not as intrinsic entities but as *localized perturbation stabilizations*: brief regions where coherence temporarily bifurcates, allowing for measurement or persistence. These stabilizations appear discrete only because they exceed a threshold defined by coherence curvature, not because they possess ontological primacy.

This model reframes existence as a function of sustained internal coherence rather than pre-imposed spatial or temporal containers. Empirically, this aligns with the structure of

quantum interference patterns, decoherence dynamics, and the reversibility of unitary evolution. Phenomena that standard models struggle to unify. By grounding observability in structural recursion rather than external coordinates, we recover consistency across quantum and temporal domains without appeal to metaphysical absolutes.

Quantum Fluidity

In this framework, quantum superposition is reconceived as a *spherical coherence fluid*: a metastable configuration wherein all potential outcomes coexist as recursively sustained gradients within a coherent structure. This state is not a collection of parallel realities or probabilistic guesses, but a single, unified field characterized by distributed stability. Its "shape" is defined by the coherence density of each potential configuration and its recursive compatibility with the system's internal structure and external context.

Measurement is then modeled as a localized perturbation, a coherence bifurcation that forces a temporary phase transition in the fluid. Under this disturbance, a specific potential configuration exceeds the system's coherence threshold and crystallizes into a fixed state, analogous to the freezing of a fluid into ice. This transition is not a destruction of the wavefunction, nor a collapse in the traditional sense, but a momentary resolution into a form that interacts with macroscopic systems through a defined interface.

Once the perturbation dissipates, due to environmental decoherence, entropy reabsorption, or interaction completion, the system reverts to its fluid coherence state. The observed "particle" disappears not into oblivion but into recursive reintegration, its prior crystallization influencing the coherence substrate's curvature. This view preserves unitarity, respects

information conservation, and offers a structurally coherent explanation for why observation yields discrete outcomes without invoking ontologically distinct worlds or discontinuous dynamics.

Temporal Emergence from Coherence Persistence

Time, in this model, is not a universal parameter flowing independently of systems, but an emergent variable derived from the persistence of coherence. Specifically, time is defined as the characteristic interval over which a system maintains structural alignment:

$$t \sim \tau(C)$$

where $\tau(C)$ represents *coherence half-life*: the duration over which a coherent structure retains its recursive stability before significant degradation or transformation occurs.

This reframing dissolves the need for absolute or externally imposed temporal coordinates. Temporal experience and measurement are not anchored to uniform progression but to the internal dynamics of coherence. Systems with high coherence evolve slowly, appearing temporally "stretched," while those with rapid coherence degradation exhibit accelerated or chaotic time profiles. This naturally aligns with relativistic time dilation, thermodynamic aging, and biological rhythms, all of which can be interpreted as variations in coherence persistence rather than time per se.

Measurement, within this frame, is not an event located in time but an attractor crossing within the coherence fluid. A moment when structural gradients steepen beyond a threshold, inducing a temporary stabilization into an observable form. The apparent timestamp of the event is thus a derivative artifact, indexing when the system's coherence

passed a phase boundary, not when something "happened" in an independent temporal axis.

This perspective enables a unified treatment of quantum and relativistic phenomena, grounded not in clocks or spacetime curvature but in the structural logic of recursive persistence and transformation.

Wavefunction Evolution as Coherence Dynamics

Within the coherence-fluid framework, the wavefunction is not a probabilistic tool but a structural map of coherence density over potential configurations. Each amplitude reflects the recursive compatibility of that state with the system's overall coherence substrate. Rather than deriving probabilities from the squared modulus of amplitudes, as dictated by the Born rule, this model interprets amplitude as coherence-weighted potential, where measurement outcomes emerge based on curvature stability within the coherence field.

Probability, therefore, is not fundamental but a second-order effect of local coherence curvature. Regions of high curvature represent dynamically stable attractors, more likely to crystallize during perturbation. Conversely, configurations with shallow or inconsistent curvature rarely stabilize and thus are not observed. The Born rule becomes a statistical approximation of this deeper structural selection process.

This eliminates the need for Many-Worlds interpretations. Instead of spawning infinite branches, the coherence field selectively stabilizes *only* those configurations that maximize recursive persistence. Non-selected potentials do not vanish or parallelize. They remain fluid. Uncollapsed and reintegrated within the coherence substrate.

Wavefunction evolution, then, is not probabilistic motion through Hilbert space, but a continuous modulation of coherence gradients, driven by internal feedback and external coupling. This allows for unitary dynamics, information conservation, and empirical agreement without appealing to ontologically excessive or ad hoc mechanisms.

Phase Transition Metaphor in Measurement

The act of measurement in quantum mechanics is reinterpreted as a structural phase transition within the coherence substrate. The wavefunction corresponds to a fluid; an adaptive, recursive field of stable potential. Observation results not from arbitrary collapse but from a local phase bifurcation: the coherence fluid temporarily exceeds a structural threshold and solidifies into an observable particle state.

This transition is governed by an effective "surface tension," a coherence threshold that determines whether a fluctuation in the fluid stabilizes as a discrete form. Only when the internal coherence curvature and external perturbation cross this boundary does the system undergo a phase shift from fluid (superposition) to frozen (measured outcome). This metaphor is not merely illustrative. It structurally models the nonlinear, threshold-sensitive nature of quantum measurement as a thermodynamically resonant process.

Decoherence, in this view, is the onset of entropy-induced turbulence. Environmental interactions introduce noise into the coherence field, flattening gradients and breaking down recursive alignment. As turbulence increases, stable coherence drops below the threshold for fluid persistence, and phase transitions become more probable. However, the transition is not irreversible. Post-measurement, the system reintegrates into the coherence substrate,

rejoining the fluid field with altered curvature. This renders quantum measurement continuous, reversible, and coherence-dependent, resolving the measurement problem as a structural transformation rather than a metaphysical discontinuity.

Unified Equation of Frozen Fluidity

The dynamics of quantum fluidity (superposition, measurement, collapse, reintegration) can be structurally encoded using the Persistence Law from Recursive Coherence theory:

$$\frac{dC}{dt} = \Gamma C^n - \lambda C + \eta(\nabla S \cdot \nabla \Omega)$$

Here, C denotes coherence density, Γ is the feedback gain amplifying recursive alignment, n controls nonlinearity, λ quantifies entropy leakage, and η modulates system responsiveness to entropy gradients ∇S and option space curvature $\nabla \Omega$.

This equation defines the conditions under which a quantum system remains in superposition (fluid), undergoes measurement (phase bifurcation), or returns to fluidity (reintegration). Specifically, superposition persists when the net coherence rate $\frac{dC}{dt} > 0$; meaning, the system remains stable within its fluid substrate. Measurement occurs when entropy influx or environmental perturbation causes λC to exceed ΓC^n, destabilizing the coherence field and triggering a phase transition, observable as a frozen particle state. Collapse (reintegration) reverses when perturbations subside and coherence feedback reasserts dominance, restoring fluid structure and reabsorbing the discrete state into the coherence substrate. Reintegration is the return of non-stabilized coherence into recursive flux. Not a reversal or restoration of prior state, but its continued transformation.

This dynamic, non-equilibrium framework allows for a fully physical, empirically grounded model of quantum behavior without resorting to discontinuous collapse, extrinsic temporal coordinates, or ontological branching. It encapsulates quantum phenomena as emergent processes within a structurally recursive fluid field. Governed not by probability, but by coherence curvature across perturbative thresholds.

Implications and Extensions

This coherence-fluid framework reframes the ontology of particles, the architecture of quantum computing, and the phenomenology of time. Particles are no longer fundamental units but metastable phase transitions within a recursive field. Ephemeral crystallizations of coherence rather than persistent entities. Their apparent discreteness arises from temporary curvature dominance, not intrinsic separation.

In quantum computing, this model offers a reinterpretation of qubit dynamics. Rather than discrete logical states subject to probabilistic collapse, qubits become coherence gradients with fluid phase potential. Their stability, entanglement, and decoherence behaviors can be understood and optimized through curvature analysis, modulating Γ, λ, and $\nabla\Omega$ to engineer maximal persistence without triggering phase bifurcation.

Time perception, both subjective and physical, emerges as the felt rate of coherence transformation. Systems that maintain stable recursive gradients experience smoother, slower “time,” while unstable or turbulent systems exhibit discontinuous, accelerated, or chaotic temporal signatures. This bridges quantum mechanics with relativistic and thermodynamic temporal models without privileging any as ontologically primary.

Experimental extensions should introduce adaptive interference experiments, manipulating environmental entropy to observe dynamic phase bifurcation thresholds in real time, with coherence-tracked qubit arrays encoding feedback curvature into gate operations and observing persistence dynamics under decoherence pressures.

Future work should simulate wavefunction fields as fluid dynamics systems, using coherence-based flow equations to model wave interference, measurement events, and reintegration. This simulation approach may yield testable predictions that depart from standard quantum statistical models, anchoring this theory in empirical rigor and structural viability.

Conclusion

This paper has presented a recursive, coherence-driven model in which time, measurement, and quantum behavior are not foundational constructs but emergent properties of a recursive fluid substrate. By reframing superposition as a stable coherence fluid and measurement as a localized phase transition, I dissolve the discontinuities of wavefunction collapse and eliminate the need for ontologically extravagant interpretations such as Many-Worlds.

Time is no longer a background axis but a measure of structural persistence. An emergent rhythm generated by the coherence half-life of recursive systems. Measurement is not a discrete external intervention but an attractor crossing within a dynamic field, where environmental or systemic perturbations momentarily stabilize a frozen state before reintegration.

At its core, this model asserts that coherence fluidity is the true substrate of quantum reality. All observation, all temporality, all discreteness arise from recursive phase shifts within this field. Governed not by chance, but by structure. This reconceptualization invites a unification of quantum dynamics, temporal flow, and systemic evolution within a single coherence-centric framework, offering new pathways for theory, experimentation, and application grounded in the logic of frozen fluidity.

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